6.1 CONTRIBUTIONS OF THE THESIS

In this thesis, energy management is proposed to solve the looming energy crisis. This is achieved by maintaining an energy balance between generation and consumption of energy. Accordingly, three specific objectives like power generation from an efficient solar cell, maximum power harvesting using efficient MPPT techniques and minimized power consumption using green light sources are chosen and executed here. In the first approach, to improve the power generation two types of MJSC namely GaP/InP/Ge and GaP/InP/Si are designed and optimised in the Synopsys/RSOFT simulation platform. The heavily doped homo junction AlGaAs tunnel diodes are used for interconnection of the subcells. The simulation under AM1.5G condition resulted in power conversion efficiency of 40.66 % and 44.39 % respectively due to low ohmic loss and close lattice matching. To further increase the efficiency, InAs quantum dots are embedded in the middle subcell of GaP/InP/Ge device so as to increase the absorption of photons. The photocurrent of this device is increased, resulting in an efficiency of 41.29 %. Apart from III-V MJSC, amorphous silicon based HIT solar cell is also designed due to cost effectiveness of the material. Simulation studies of this device produced a power conversion efficiency of 25.91 % which is higher than the existing cell.

In the second approach to harvest the maximum power from the solar panel, voltage based feed forward and feed backward PWM controllers are designed and implemented. The developed feed forward PWM controller is tested in the real time varying atmospheric conditions which resulted in tracking efficiency of 97.48 % in clear sky condition and (92.64 – 95.49) % in partial shading conditions. Similarly, the feed backward PWM controller is developed and tested resulting in tracking efficiency of 94.03 %. Both the tracking techniques are validated by comparing their performance with other existing techniques that showed a significant improvement in the proposed technique.
In the third approach of reducing the power consumption, green light sources are recommended for use. To assure this, a comparative analysis on the performance of different light sources is required. So, a classroom model is designed and simulated in DIALux with different conventional and energy efficient light sources. Based on the photometric results and annual energy estimation, it is observed that both CFL and LED lighting systems are consuming less power compared to other lamps. But LED lamps have good photometric characteristics compared to CFL and other conventional light sources. To prove this, in reality, a study on readability of students under CFL and LED lighting condition is performed. Test results also proved that LED lighting system offers better visual contrast, comfort, visibility and enhances the readability as well.

Finally employing all the three techniques, an autonomous solar PV powered classroom model with LED lighting system is designed. The design is carried out by considering the realistic constraints and then sizing of the panel and batteries are decided. The whole set up is simulated and its performance is observed for reliability. The key contributions of the thesis are the design of high power conversion multi junction solar cells, efficient tracking systems to extract maximum power from the solar panel and using green lights to reduce power consumption. This research work has certain limitations for implementation, as it depends mainly on the solar energy. It is abundant in nature but will not be available uniformly throughout a year in all parts of the world. Hence, factors like capital expenditure, storage mechanisms, area of installation and climatic conditions should be considered before implementing this work. This complete design procedure can be adopted for any stand-alone solar power indoor applications that are independent of grid supply.

6.2 FUTURE SCOPE

In the near future, renewable energy will become the dominant source for producing electric power due to a great awareness that raised all around the world. To make the power production sustainable and cost effective, the best solution is the development of multi junction solar cells. They have tremendous potential to meet the energy requirements of the globe. In the current century, research is being carried on development of lattice matched triple junction and quadruple junction solar cells for high
efficiency and is expected to move further with penta and hexa junctions with apt absorbing materials in the future. To increase the photocurrent, nano structures in the form quantum wells and quantum dots are employed in MJSC. These nano structures composed of semiconductor materials can be improved with better absorption characteristics. Since the amorphous silicon material is economically cheap and has varying conductivity, possibilities are there to design HIT solar cells with different combination of materials. The solar PV research group is targeted to develop solar cells with efficiency greater than 60% in the near future. The generated power should be completely extracted without loss, so digital MPPT controller with effective tracking technique will be possible. Even after extraction of power, it should be saved for future use. So better storage batteries with long span and low loss characteristics are required. On the other hand, development of LED lamps with high thermal stability is the challenge now which could be improved in the near future.

Finally, the Solar PV LED lighting systems could be used in different areas where the grid connections are not feasible in near future. Specially in the developing countries where there is increasing demand for energy and increasing consumption of energy due to lighting for residential, commercial, industrial and street lighting systems. So, the future scope would be to design and construct solar PV LED street lighting systems employing PWM technology and to estimate the overall cost involved. The performance of the system could be recognized in future. Also to learn about the pay back of a solar PV LED street lighting system against a predictable grid LED street lighting system.